

Analysis of the DFP/AFCS Systems for Compensating Gravity Distortions on the 70-meter Antenna

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The gain performance of the 70-meter antenna falls off rapidly as the antenna is pointed at targets either above or below the elevation angle for which the antenna was optimized. This antenna roll-off was measured to be 2.5 dB at 10 degrees elevation and 6.4 dB at 80 degrees elevation. Techniques for improving the antenna's performance include a deformable mirror and an array feed. The deformable flat plate, which will be inserted in the optical ray path of the antenna, compensates for the gravity distortion of the antenna main surface by phase conjugate deformation, thus restoring the focal point of the antenna. The Array Feed Compensation System (AFCS) utilizes signal combining and tracking from a seven element array feed. It combines the distributed energy in the focal plane of the antenna due to a gravity induced defocusing, and also provides for closed loop tracking. The AFCS combines the two functions of gravity distortion compensation and closed loop tracking into one system. The DFP combined with a monopulse tracking system also provides the same two functions.

This paper presents the theoretical computations showing the expected performances for both systems. The basic analysis tool is a Physical Optics reflector analysis code that was ported to a parallel computer for faster execution times. There are several steps involved in computing the RF performance of the various systems.

1. A model of the RF distortions of the main reflector is required. This model is based upon measured holography maps of the 70-meter antenna obtained at 3 elevation angles. The holography maps are then processed (using an appropriate gravity mechanical model of the dish) to provide surface distortion maps at all elevation angles.
2. From the surface distortion maps, ray optics is used to determine the theoretical shape of the DFP that will exactly phase compensate the distortions.
3. From the theoretical shape and a NASTRAN mechanical model of the plate, the actuator positions that generate a surface that provides the best RMS fit to the theoretical model are selected. Using the actuator positions and the NASTRAN model provides an accurate description of the actual mirror shape.
4. Starting from the mechanical drawings of the feed, a computed RF feed pattern is generated. This pattern is expanded into a set of spherical wave modes so that a complete near field analysis of the reflector system can be obtained.
5. For the array feed, the excitation coefficients that provide the maximum gain are computed using a phase conjugate technique.

The basic experimental geometry consisted of a dual shaped 70-meter antenna system; a refocusing ellipse, a DFP and an array feed system. To provide physical insight to the systems performance, focal plane field plots are presented at several elevations. Curves of predicted performance are shown for the DFP system, monopulse tracking system, AFCS and combined DFP/AFCS system. The calculated results show that the combined DFP/AFCS system is capable of recovering the majority of the gain lost due to gravity distortion.